An Overview of Composite Materials Technology and Their Development in Multisectorial Applications

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Abstract— **In this articles it is presented a introduction about composite materials, the methods to obtain the thermoset composites and some generalities about the domain there the composite are used.**

Keywords- composite materials; fiber; resin.

I. INTRODUCTION

The composite materials have received a special attention in the last years, because have unusual properties, sometimes unique, which could lead in different applications in technology domain. Their properties depend on the particle size and therefore the dispersion level of composite particles is a factor that affecting the composite properties.

An another factor that influence the properties of the composite materials is the interaction surface between the host matrix and particles [1]. A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone [2].

Composite material is composed of a base material called matrix which has low properties, but low cost price, reinforced with other materials in the form of continuous fibers, short fibers or particles with mechanical physical or chemical properties.

In addition to these properties can be obtained by inserting with nanoparticles composite material with high conductivity. Composites manufacturing processes can be subdivided into two main manufacturing categories: manufacturing processes for thermoset composites and manufacturing processes for thermoplastic composites [3].

Thermoset composites are commonly based on glass, carbon or aramid fibres, usually incorporated with resins such as polyesters, vinyl esters, epoxies or phenolics [4]. In terms of commercial applications, more than 75% of all composites are made of thermoset composites. Their uses predominate in the aerospace, automotive, marine, boat, sporting goods, medical technology and consumer markets**.**

Composite material are commonly classified at two distinct levels**.** The first level of classification is made by the type of material used for the matrix [5, 6, 7].

The major composite classes include:

- organic-matrix composites (OMCs) which include two classes of composites: polymer-matrix composites (PMCs) and carbon-matrix composites (commonly referred to as carbon-carbon composites);
- metal-matrix composites (MMCs);
- ceramic-matrix composites (CMCs).

The polymer-matrix composites can be divided in two categories: thermoplastics (PE, Nylon, PS, PP, PC, and PVC) and thermosets (epoxy, polyester, phenolics) composites.

The second level of classification refers to the reinforcement form—particulate reinforcements, whisker reinforcements, continuous fiber laminated composites, and woven composites (braided and knitted fiber architectures are included in this category) [8].

II. MANUFACTURING PROCESS OF THERMOSET COMPOSITE MATERIALS

Composite materials have many processes, it this articles will be presented some of the most important processes for thermosetting matrix composite such as:

- Hand Lay- up;
- Spray Lay-up;
- Filament Winding;
- Resin Transfer Molding;
- Pultrusion.

A. Hand Lay-up

Is a simple method for composite materials production. It can be used any type of thermoset resin, such as epoxy, vinyl ester and phenolic. The fibers used as the reinforcing extend to the full fiber range mode and high resistance generally as 2D-woven fabric, knitting, fiber beds. The basic principle of the process is shown in Fig. 1 [9].

The reinforcing material is deposited on the mold, the resin is stretched with a roller on the surface. Cleaning can be done at room temperature or in an oven at 80°C depending on the resin used. To prevent adhesion problems that may occur when removing the material, the mold is recommended to apply a protective layer evenly with a thickness of about 0.35 mm.

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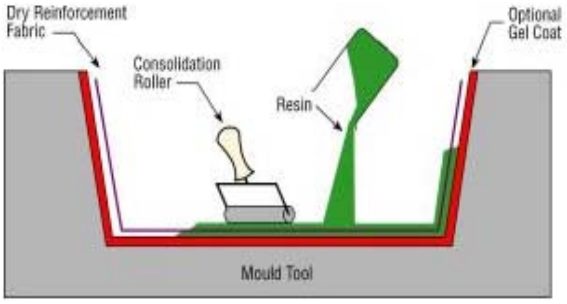

Figure 1. Hand lay-up process.

The most commonly materials used are: gels, waxes, silicones, carbon compounds etc. The main advantages of the process are: the technique is simple and very prevalent; the equipment is inexpensive; can be used any kind of fiber.

B. Spray Lay-up

Is a type of molding mechanized in contact that allows to reduce the overall cost of the laminate, using a "ravings", together with continuous filaments of glass fibers, instead of more expensive materials. This technique allows to reduce the time of application, the impregnation of the reinforcement and to eliminate the waste baths resin that is not used.

The spray-up method is an open mold in which the roving and catalyzed resin is deposited in the same time into the mold by a spray gun and a plunger. In order to compact the fibers in the resin and cast out the trapped air are used rollers. As in the case of manual lay-up, is most commonly used applying a gel-coat to the mold in order to improve the finish surface of the work piece and to facilitate removal.

The equipment for manipulation of the resin can be divided into systems mixing an equal parts resin from a resin bath catalyzed and accelerated resin. Fig. 2 presents a system that makes use of resin with accelerant by one or more baths and by another with a pure solution of catalyst [9].

The resins are generally unsaturated polyester which has a viscosity of 40-60 Pa/second at 25° C for rapidly wetting the fibers. The equipment for cutting the roving into short fibers consists of two rollers, one steel fitted with blades and the second made from rubber.

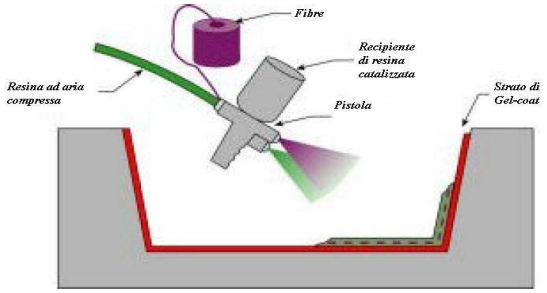

Figure 2. The principle of the spray lay-up process.

The characteristics of the composite are influenced by the flow rate of fiber where this parameter must be developed and closely monitored during the process. Is usually used the polymerization at room temperature, but in some cases use is made of a moderate flow of heat to accelerate the process of production.

C. Filament winding

Is a process of manufacturing the composite material reinforcement of continuous type (filaments, fires, tapes, etc.) impregnated with resin before or during the process, are deposited on a rotatable form, so that they meet certain conditions related to the voltage in the winding. In general, the area form is tubular, closed and opened [10].

After the winding desired number of layers is created and removed all supported formats. Filament winding can be made on the circumference of support form or including the form heads, so-called polar winding.

Winding on the circumference form is obtained by using a trolley which carries filaments along the surface. The correlation between the form and trolley movement determines the type of winding - cross or parallel, and the angle value of winding. In order to improve the mechanical properties can be inserted filaments, fires and tapes in the longitudinal direction [7].

In the polar winding the filaments are deposited from one end to another, thus creating a closed form. In Fig. 3 is illustrated the scheme of technological winding filaments process cross type, in case of a wet process [9].

If the winding is made in an earlier phase similar with the introduction of matrix reinforcement system (using so-called "prepregs"), then the process is dry type. Wet process is characterized by reinforcement passing through a resin bath.

Composite materials produced by filament winding are used in aviation and aerospace industry for components such as rocket engines, fuselages, propellers helicopters, tanks and pressure vessels.

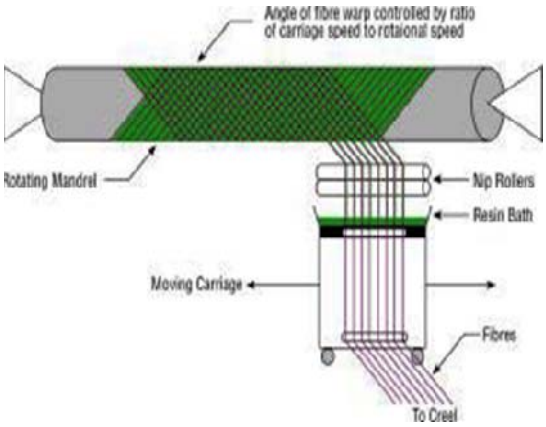

Figure 3. Winding filaments process.

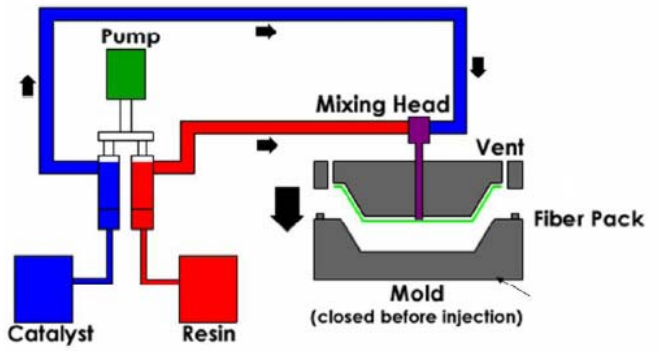

Figure 4. Schematic resin transfer molding process.

D. Resin Transfer Molding Process

The Resin Transfer Molding (RTM) process (Fig. 4) is a cost-effective fabrication method for the manufacture of polymer composites [11]. In a traditional RTM process catalyzed thermosetting resin is injected into an enclosed metal mold containing a previously positioned reinforcement perform.

The perform is compacted to the specified fiber volume fraction when the matched metal mold is closed. The resin wets out the fiber until the mold is filled, and the part is then cured inside the mold [11].

This methods present some advantages such as: reinforcement and combination of reinforcements can be used to meet specific properties, production cycles are much faster than with wet lay-up large complex shapes and curvatures can be made easily; and some limitation: mold design is complex and requires mold-filling analysis, reinforcement movement during resin injection is sometimes a problem [12].

E. Pultrusion

Pultrusion is a continuous process of manufacturing composite materials (Fig. 5) with constant cross-section whereby glass reinforced fibers – roving and mats – are pulled through a thermoset resin basin, followed by a separate performing system and into a heated die where the resin undergoes polymerization [13]. During pultrusion, the fiber reinforcements are saturated with the resin, in a resin tank and then continuously pulled through a heated die by a puller [14]. Inside the die, the resin gradually cures and solidified to form a composite part with the same cross sectional profile as the die [14].

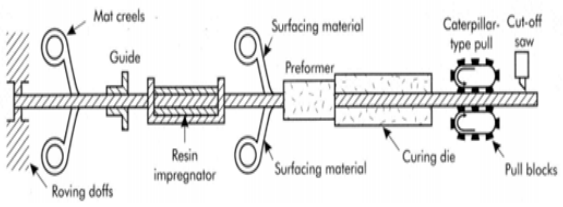

Figure 5. Pultrusion process.

On leaving the polymer bath impregnated fabric passes through a number of remote devices excess progressive of resin. There can be one or two thermal regimes depending on the size and complexity of form.

III. Application Fields

A. Automotive Applications

Composites provide a wide range of potential automotive applications—body panels, suspension, steering, brakes, and other accessories—where the demand varies widely by application.

The automotive industry is one of the main user of composite materials. The evolution of consumption of composite materials in automobile industry is perfectly justified by their quality and low cost which lead to substantial benefits for both producers and consumers [15].

B. Aerospace Industry

In the aerospace industry, which were first applied, shows a very high utilization rate. Aerospace industry use materials such as carbon fibers, boron, aramid, wiskers's, metal composites, polymers and ceramics[16].

C. Telecomunications

Telecommunications, is the further development of composite materials are used for isolation the telephone cables by polyethylene in high and low pressure, at satellite transmissions where the resistance structures and antenna discs are used glass fiber reinforced composites.

D. Medical Field

The most famous achievements in medical field of composite materials include: surgical implants, artificial organs (artificial skin, lung transplantation, blood vessels, dental implants), electronic medical equipment, props, splints, drainage tubes, carts.

E. Chemistry Field

Is one of the largest consumers of composite materials which present high resistance to chemical action, long service life, excellent dimensional stability at heat.

IV. Conclusion

Composite materials are considered to be competitive in terms of price and possibilities for successful replacement completion of traditional materials (metal, ceramic, glass). Composite materials present some advantages:

- High resistance to fatigue and corrosion degradation;
- High strength or stiffness to weight ratio;
- Due to a better reliability, there are fewer inspections and structural repairs;
- Directional tailoring capabilities to meet the design requirements. The fibre pattern can be laid in a manner

that will modify the structure to competently sustain the applied loads;

- Present improved torsional stiffness. This implies high whirling speeds, reduced number of intermediate bearings and supporting structural elements. The overall part count and manufacturing and assembly costs are thus reduced;
- Composite are dimensionally stable, they have low thermal conductivity and low coefficient of thermal expansion;
- Can be tailored to observe with a broad range of thermal expansion design requirements and to reduce thermal stresses;
- Exceptional heat sink properties of composites, especially Carbon-Carbon, combined with their lightweight have extended their use for aircraft brakes.

Disadvantage of composites:

- Raw materials and fabrication with high cost;
- Composites are more delicate than wrought metals and thus are more easily damaged;
- Transverse properties may be weak;
- Matrix is weak, therefore, low toughness;
- Difficult to attach.

Repair introduces new problems, for the following causes:

- Materials need refrigerated transport and storage and have limited shelf life;
- Hot curing is necessary in a lot of cases requiring special tooling;
- Hot or cold curing takes time;
- Analysis is hard.

Thermoset-based products, in particular, thermoset composites and blends constitute a major source material for the production of automotives, aeronautics and electronic components.

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